Monetary Exit Strategy and Fiscal Spillovers [1]

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Abstract

The aftermath of the global financial crisis has seen two types of concerns in regards to monetary policy outcomes. Some (eg Paul Krugman) worry primarily about the short-term possibility of deflation caused by a prolonged slump. In contrast, others (eg John Taylor) worry more about excessively high inflation in the longer-term caused by recent bailouts/quantitative easing and political pressures to monetize intertemporal fiscal shortfalls. To assess these concerns the paper makes three contributions to the literature. 1) Our macroeconomic contribution is to model monetary-fiscal interactions jointly over both horizons, and in a sense endogenize Leeper's (1991) active/passive policy regimes. The focus is on the *strategic* aspect of the policy interactions under uncertainty about the recovery prospects as observed around the globe in 2010-2011. 2) Our methodological contribution is to incorporate institutional features such as fiscal rigidity through a novel game theoretic framework. It allows for stochastic revisions of moves and generalizes the Stackelberg leadership concept from static to dynamic. The analysis shows, perhaps surprisingly, that (i) the probabilities of short-term deflation and of long-term high inflation in a given country are *positively* related, and that (ii) a legislated long-term monetary commitment may reduce both. This is because such commitment (eg a numerical target for average inflation) makes a costly tug-of-war between monetary and fiscal policy less likely. We extend the analysis to a monetary union and show that monetary commitment is less effective due to fiscal free-riding. 3) Our empirical contribution is to quantify fiscal rigidity and monetary commitment in developed countries, and use them to predict future monetary and fiscal outcomes.

Keywords: monetary-fiscal interactions, fiscal stress, deflation, active/passive policy, Game of Chicken, asynchronous moves, stochastic timing, equilibrium selection. **JEL Classification Numbers:** E52, C70.

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'By establishing an inflation objective at this juncture the Fed can guard against both of these problems. Providing a firm anchor for long-run inflation expectations would make the threat of deflation less likely. But a firm anchor would ... [make] an upward surge in inflation expectations less likely too.' Mishkin (2010)

1. Introduction

The aftermath of the global financial crisis (GFC) has presented policymakers all over the globe with major challenges. In relation to monetary policy outcomes, high uncertainty about economic conditions has made it difficult to assess the danger that: (i) their economy may fall into a *deflationary* trap in the short-term; and that (ii) past fiscal and monetary actions combined with demographic trends may have *inflationary* consequences in the long-term.

In terms of the short-term, by the end of 2011 the unemployment rate in the United States had been close to 10% for almost two years despite interest rates at zero. Coupled with GDP growth rates and inflation consistently below the historical average this led to fears of a double-dip recession. In terms of the long-term, by the end of 2011 the balance sheet of the Federal Reserve had tripled in size from September 2008, the Congressional Budget Office's projections showed debt on an explosive path, and the World Economic Forum ranked 'fiscal crises' as the number one global risk in terms of the perceived financial losses (ahead of climate change, asset price collapse, and geopolitical conflict).[3]

The main contribution of the paper is to offer a way of modelling both the short-run and long-run aspects of a post-downturn situation, and the linkage between them. This qualitative analysis is complemented by a quantitative assessment in order to better predict likely monetary and fiscal policy outcomes in advanced countries, and formulate policy recommendations for the post-GFC period.

We postulate the monetary (M) vs fiscal (F) interaction as a game between the central bank and the government in the presence of an underlying intertemporal budgetary shortfall [the so-called 'fiscal gap', see Kotlikoff (2006)], as well as incomplete information about the economy's recovery prospects. Each policy can engage in an '*active*' (A) or '*passive*' (P) *stance*. These are defined differently from the seminal contribution of Leeper (1991) depicting his two polar cases. Our A policy stance provides no adjustment to balance the long-term budget constraint, whereas the P policy stance provides the full adjustment necessary. Specifically, passive fiscal policy PF can balance the budget constraint via a F reform in which future taxes and government expenditures are aligned, whereas passive monetary policy PM can do so by inflating promised net transfers and/or the accumulated debt away similarly to Sargent and Wallace (1981).

As the A vs P policy regimes in Leeper (1991) and the subsequent literature are exogenous, our aim is to *endogenize* them, ie derive the equilibrium regimes that obtain in the short-term and long-term. In doing so we focus on the *strategic* interactions between the M and F policymakers that are not captured in standard macroeconomic models. The developments of the past few years however suggest that strategic considerations may be crucial in determining the outcomes of both M and F policies - even if the central bank is formally independent from the government. For example, the European Central Bank's initial resistance to quantitative easing, and its subsequent change of

[3]Appendix A provides a discussion of fiscal stress in advanced countries.

view suggest that strategic interactions between M and F policy need to be taken into account, and formally modeled. The importance of strategic considerations is likely to grow over time as countries face increasing F stress from aging populations.

Game Theoretic Framework. To focus on the policymakers' strategic behaviour we use game theoretic methods rather than a DSGE model. Our methodological innovation is to generalize the timing of the game allowing for arbitrary (stochastic or deterministic) revisions of moves. Specifically, after an initial simultaneous move (one of) the policymakers can revise the previous policy stance with some probability - but not necessarily with certainty, and only with a delay.[4] This is in contrast to the standard repeated game, in which moves are made simultaneously every period, alternating move games of Maskin and Tirole (1988) in which players alternate every other period, or the Stackelberg leadership in which the revision is immediate. Neither of these existing setups seems realistic in the M and F policy context.

Such generalized timing enables us to examine the role of institutional factors that make policies more pre-committed to their past actions. The two main factors considered are the degree of F rigidity, and the strength of long-term M commitment. Both reduce the ability of the policymakers to revise their previous stance, and as such affect the leadership in the game.[5] Note that unlike the standard Stackelberg leadership concept which is static, our leadership concept is *dynamic*. In particular, in the standard framework the follower can revise his action immediately, ie there is no cost to the leader from mis-coordination or conflict. In contrast, our framework allows for such costs as the revision may arrive later in the game and payoffs accrue over time.

Policymakers. In addition to differences in policy timing, the presence of a large F gap (unfunded liabilities) also implies divergent objectives of the two policymakers. Following the literature, eg Faust and Svensson (2001), the central bank is 'responsible' but the government is 'ambitious', and each thus prefers a different regime.[6] This means that we no longer have the M and F 'symbiosis' of Dixit and Lambertini (2003), but a potential coordination problem and/or outright conflict between the policies.

In particular, in our game - which we obtain from a simple macro setup justified by the observed developments during 2010-2011 - each policymaker prefers the *other* policy to deal with the underlying problem: the weak recovery in the short-term and the F gap in the long-term. Therefore, our analysis can roughly be interpreted as examining the following question: *'Which policy, if any, will be 'induced' to deal with the short-term threat of a double-dip recession, and which with the long-term F shortfall?'*

Uncertainty. To capture the high degree of uncertainty regarding economic conditions in the aftermath of the GFC during 2010-2011, we allow for policymakers' incomplete information. They are unsure which game they are playing. They believe that with

[4]The timing of the revision opportunity, described by an arbitrary probability distribution, is assumed exogenous and common knowledge, but it can be private information and/or endogenized.

[5]We will throughout talk about *long-term M* commitment to distinguish it from the popular but quite different concept of timeless perspective commitment.

[6]In addition to future determinants such as unfunded health/pension schemes in the presence of an aging population, government's ambition may be due to past drivers such as accummulated debt (eg Greece) or public liabilities for financial institutions (eg Ireland). For completeness in Section 6 we will also consider the case of a monetary union in which some governments are responsible and therefore not in conflict with the common central bank.

probability $(1-p)$ economic conditions will keep improving, and the economy recovers at a good pace without any additional stimulatory measures. This is our '*Normal times*' scenario depicting the long-term perspective, which takes the form of a Game of Chicken. In contrast, the policymakers believe that with probability p economic conditions are such that a double-dip recession and deflation are imminent without a policy stimulus. This is our '*Downturn*' scenario depicting the short-term perspective of stabilizing adverse cyclical deviations, which takes the form of the Battle of the Sexes. Many papers have the conflict/coordination features, and hence point to these two classes of games.[7]

While we assume that the two policymakers have the same estimate of (an exogenous) p, we do not restrict this value to reflect the fact that in the real world it varies over the business cycle. One of the aims of the paper is to identify 'business-cycle-proof' institutional characteristics that deliver optimal outcomes for all p.

Findings. We show how the equilibrium regimes, both short and long-term, depend on the *relative* inability of the policies to change their previous stance (as well as several other variables). This is because this inability determines which policy imposes itself as the leader in the game, and how strongly so. Specifically, we identify three equilibrium regions determined by the $\frac{M \text{ commitment}}{F \text{ rigidity}}$ ratio:

(1) *Monetary dominance* - M is the leader and this ratio is above a threshold T_F;
(2) *Fiscal dominance* - F is the leader and this ratio is below a different threshold;
(3) *Regime switching* - the ratio is in the intermediate interval.

In the M-dominance case inflationary F spillovers will surely be avoided. A strong long-term M commitment gives the central bank ammunition to counter-act excessive F stance - yielding the Ricardian regime (AM, PF) in Normal times. This region is implicitly assumed by most existing papers. In contrast, in the F-dominance case inflationary F spillovers will surely occur because F rigidity gives the government an upper hand in the policy tug-of-war. The M exit strategy will be unsuccessful as we have the non-Ricardian regime (PM, AF). Sargent and Wallace's (1981) unpleasant arithmetic and Leeper's (1991) Fiscal Theory of the Price Level (FTPL) fall into this region.

Importantly, we show how in both regions deflation is prevented in the short-term equilibrium. This is because the dominant policy can indirectly induce the dominated policy to provide the required stimulus in the Downturn scenario.

The Regime switching region is of particular interest as it does not exist under static (Stackelberg) leadership. In this region leadership no longer ensures a player's dominance. One policy is still the leader in the game - more committed/rigid than the other - but insufficiently so to force the opponent to cooperate. This increases the likelihood of a policy tug-of-war, which is costly for both policymakers and society. The conflict has the form of a 'waiting game'; both policies delay required actions hoping to induce

[7] For example Adam and Billi (2008, 2006), Branch, et al. (2008), Benhabib and Eusepi (2005), Dixit and Lambertini (2003a,b), Barnett (2001), Blake and Weale (1998), Nordhaus (1994), Sims (1994), Woodford (1994), Leeper (1991), Petit (1989), Alesina and Tabellini (1987), or Sargent and Wallace (1981). While these papers contain a wide range of modelling approaches and macroeconomic environments, our insights relate to their common conflict/coordination features, and are therefore applicable to all these papers. In Appendix B we show how the the Game of Chicken and the Battle of the Sexes can be derived from a standard intertemporal budget constraint of the government and conventional quadratic policy preferences under reasonable circumstances.

the other policy to carry them out. In the Downturn scenario they postpone necessary (conventional or unconventional) stimulatory measures making a double-dip recession accompanied by deflation likely.[8] In Normal times they postpone dealing with the F gap which brings the economy closer to a F crisis.

This means that countries in the Regime switching region are more likely to see *both* deflation in the short-term and high inflation in the long-term compared to those in the M-dominance region. As such, the probability of these two phenomena may be positively (rather than negatively) related - despite their opposite nature. Furthermore, under reasonable circumstances the threshold T_F is increasing in p. Therefore, a certain degree of M commitment that is sufficient to avoid inferior M outcomes in normal times may be insufficient in the aftermath of a downturn such as the GFC.

None of these outcomes can occur under static leadership, which highlights the importance of using dynamic leadership to avoid inaccurate policy prescriptions.

Policy Implications. In Section 5 we carefully relate our findings to the real world. We develop summary indices of F rigidity and M commitment based on a number of existing measures in the literature. The analysis shows that while countries such as Australia and New Zealand seem safely in the M-dominance region, countries such as the United States and Japan are likely in the F-dominance or Regime switching regions. Our results thus imply a higher probability of both short-term deflation and long-term high inflation in the latter pair of countries.

Our analysis' main M policy implication in an environment of large F gaps is as follows. In order to minimize the probability of both deflation in the short-term, and of subsequent inflationary F spillovers (ie maximize the credibility of a M exit strategy), the central bank should be as strongly committed as possible in the long-term. Such commitment acts as a '*credibility insurance*' over the business cycle, as it delivers optimal outcomes for any value of p.

In practice, long-term M commitment has commonly been implemented as a legislated numerical target for average inflation for which the Governor is accountable. A recommendation to adopt such explicit commitment has been recently made by a number of economists, both for short-run and long-run reasons, eg Bernanke (2003), Goodfriend (2005), Hamilton (2008), Walsh (2009), or Mishkin (2010). The above quote by the latter author summarizes these views - stressing desirable effects over both horizons in line with our findings. The fact that the Federal Open Market Committee (FOMC) subscribed to the 2% long-term inflation target more explicitly in its January 2012 statement is in line with these recommendations.[9]

Interestingly, our analysis implies that an explicit M commitment may improve not only M outcomes, but also F outcomes. By reducing the structural incentives of the government to spend excessively through a credible threat of a policy conflict, a more explicit long-term M commitment can under some circumstances discipline F policy and

[8] Furthermore, as an important policy warning, the analysis shows that a higher estimated cost of deflation actually increases the probability of deflation, as it increases the range of parameters under which the waiting game can occur in equilibrium.

[9] It is important to note that the commitment to low inflation does not need to be focused on consumer prices, but can in principle use a broader measure of inflation.

help gain political support for necessary F reforms. We report below some empirical evidence for this 'disciplining effect'.

Nevertheless, in our extension to the case of a M union we identify an important caveat. If a free-riding problem exists in the currency union, whereby some governments do not internalize the negative externality their F profligacy imposes on other members, then even an infinitely strong M commitment of the common central bank may be ineffective in avoiding deflation in the short-term, and high inflation in the long-term. As free-riding governments cannot be disciplined by the common M policy, some direct enforceable F rules are necessary. Naturally, such F commitment is beneficial in countries with their own currency as well, among other because it better anchors F expectations.

Let us acknowledge that in focusing on a dynamic game with stochastic timing of moves our analysis abstracts from the dynamic adjustment to the equilibrium active/passive regime. Therefore, the analysis is unable to provide insights into the dynamics of debt, or how expectations are affected as the economy approaches its F limit. This implies that while our paper is consistent with Leeper's (2010) call for '*more attention to information and uncertainty, ... and more focus on institutional design*', his call for '*more dynamic modelling*' is only answered at the game theoretic level, not at the macroeconomic level.[10]

2. The Policy Interactions Under Incomplete Information

To be able to focus on the strategic aspects of the policy interaction and incomplete information we will present it as the following 2×2 games

(1)

		F	
		PF	AF
M	AM	a, w	b, x
	PM	c, y	d, z

Normal times: probability $1 - p$

		F	
		PF'	AF'
M	AM'	a', w'	b', x'
	PM'	c', y'	d', z'

Downturn: probability p

2.1. **Normal Times.** Attempting to accurately represent the economic environment of 2010-11, we make the following assumptions about the Normal times scenario (which is expected by both policymakers to occur with probability $1 - p$). First, there exists a sizeable F gap - government's unfunded liabilities mandated by existing legislation. This is uncontroversial given the observed demographic trends, see Appendix A for some data and a discussion. Second, we assume that in the Normal times equilibrium the budget constraint has to be satisfied, ie at least one policy needs to be passive. This effectively rules out default on debt in the long-run as an ongoing long-term solution. Third, both policymakers prefer the *other* policy to play P and balance the budget constraint. This is because the central bank dislikes deviations from price stability, and the government dislikes reneging on promises of high transfers and low taxes.

[10] This is driven by our belief that the observed and predicted F imbalances dictate increased focus on the first moment (steady-state debt and inflation levels) as opposed to the second moment (debt and inflation variability) emphasized in most DSGE models. This parallels the developments in the literature whereby the high inflation of the 1970s led to a focus on 'inflation bias', whereas once inflation fell to low levels the focus switched to the 'stabilization bias'. The dire F projections and their possible M implications ala unpleasant monetarist arithmetic suggest to us that switching back may be in order.

To keep our focus on the game theoretic insights under general timing, we relegate the formalization of these assumptions to Appendix A. It postulates the long-term budget constraint, and discusses the sources of F stress and its solutions. This is then used to give a formal definition of the $\{AM, PM, AF, PF\}$ policy stances, and to derive the steady-state debt outcomes in each policy regime. The following table summarizes them, and indicates (in large letters) which policy deals with the underlying F gap:

		F	
		PF	AF
M	AM	Stable real debt Fiscal Stable nominal debt	Rising real debt Neither Rising nominal debt
	PM	Falling real debt Both Stable nominal debt	Stable real debt Monetary Rising nominal debt

While in the (AM, PF) and (PM, AF) regimes the budget constraint is balanced by F and M policy respectively, in the (AM, AF) regime neither policy is adjusted, and hence debt is on an explosive path, both in nominal and real terms. Therefore, the latter cannot be an equilibrium in Normal times. Finally, in the (PM, PF) regime both policies contribute towards the budget constraint in an uncoordinated fashion and therefore real debt is actually falling.[11]

Finally, Appendix A introduces utility functions for the policymakers. In line with Leeper's (1991) policy rules, the primary goal of the central bank is to achieve stable prices (low inflation). In contrast, the government suffers disutility from volatile real debt and from reneging on its promises of net transfers. This implies that in Normal times AM and PF can be interpreted as long-term *discipline*, and PM and AF as *indiscipline*. This is because, absent of the influence of the other policy, the policy's primary target is on average delivered in the former case, and over-shot in the latter.[12]

The utility functions are used in Appendix A to show how the underlying macroeconomic structure can be mapped into the above 2×2 game. It is shown that our three assumptions imply the Game of Chicken in Normal times, ie the payoffs in (1) satisfy

$$a > d > \max\{b, c\} \quad \text{and} \quad z > w > \max\{x, y\}. \tag{2}$$

The following payoff matrix offers an example using specific values of the policy parameters, with the Nash equilibria indicated in bold (for details see Appendix A)

(3)

		F	
		PF	AF
M	AM	Ricardian $\mathbf{0}, \mathbf{-3}$	tug-of-war $-4, -4$
	PM	tug-of-war $-4.05, -3.25$	monetization/FTPL $\mathbf{-3.8}, \mathbf{0}$

Game of Chicken

[11] In Leeper's (1991) setup the (PM, PF) outcome leads to indeterminacy. To avoid this we pin the PM stance down by the exact size of unfunded net transfers, see Definition 2 of Appendix A.

[12] Note that PF can also be interpreted as an intertemporarilly balanced budget (including factors such as the government's implicit guarantees for financial institutions). This is in line with Leeper and Walker (2011) who highlight *'the importance of building in the possibility of adopting a policy rule that incorporates a balanced budget.'*

The intuition of the Game of Chicken closely resembles the unpleasant monetarist arithmetic of Sargent and Wallace (1981). There are two pure strategy Nash equilibria, each preferred by a different player. The central bank wants to deliver stable prices, and an intertemporarilly balanced budget allows the bank to do so. Therefore, the bank prefers the socially optimal 'Ricardian' outcome (AM, PF). In contrast, the government prefers to avoid necessary F reforms for political economy reasons, and would like the central bank to inflate some of the promises/debt away. Therefore, the government's preferred outcome is the 'non-Ricardian' outcome (PM, AF).[13] If the policymakers do not coordinate their actions, for example if they play the mixed strategy Nash equilibrium, they get inferior off-diagonal outcomes.

2.2. **Downturn.** We make the following five assumptions about the Downturn scenario (which is believed by the policymakers to occur with probability p). First, as adverse economic conditions continue, the economy requires a potent expansionary response in order to fully recover. If neither policy responds, or we only have a Ricardian type response in which future taxes are expected to rise to offset the current budget shortfall, the economy experiences a prolonged recession and possibly a deflationary/liquidity trap.

Second, M and F policies are substitutes in providing the required stimulus. This can be interpreted both in terms of conventional policies (lower interest rates and higher government spending respectively), as well as unconventional ones. In terms of the latter Barro (2010) argues: '*My conclusion is that QE2 may be a short-term expansionary force, thereby lessening concerns about deflation. However, the Treasury can produce identical effects by changing the maturity structure of its outstanding debts.'*

Third, the intertemporal budget constraint may not be satisfied in the Downturn equilibrium. As a justification of this assumption see eg Davig and Leeper's (2010) estimates showing the occurrence of the (AM, AF) regime under Reagan/Volcker.[14]

Fourth, we assume that a joint expansionary response of both policies, (PM', AF'), may be excessive and over-heat the economy, potentially planting seeds for imbalances in the future. This assumption can be motivated by eg Taylor and Ryan (2010) who argue: '*The Fed's decision to hold interest rates too low for too long from 2002 to 2004 exacerbated the formation of the housing bubble.*'[15]

Fifth, both policymakers prefer the other policy to stabilize the shock: the central bank prefers (AM', AF'), whereas the government prefers (PM', PF'). This is because the policymakers understand that their additional stimulatory measures jeopardize the pursuit of their preferred Normal times regime once the Downturn threat is over. For example central banks may resist further QE on the grounds that it will make the subsequent exit strategy harder and less credible. As Barro (2010) argues: *'The downside of QE2 is that it intensifies the problems of an exit strategy aimed at avoiding the inflationary consequences of the Fed's vast monetary expansion.'* Similarly, additional

[13]Such government preferences can be derived from an overlapping generations model with an aging population. See Kuehnel (2011) for formal modelling of how this '*shifts political power from the young to the old*'. Davig and Leeper (2010) show that since 1985 the Ricardian and non-Ricardian regimes were most prevalent in the U.S., which also indicates the Game of Chicken.

[14]This, together with the first assumption, are the two key differences between the Normal times and Downturn scenarios.

[15]Similar concerns can be heard about the policy behaviour in the post-GFC period, eg Rajan (2011).

conventional F measures deteriorate the long-run fiscal position, and make it difficult for the government to engage in politically popular spending programs in the future. The same is true for unconventional F measures that increase the rollover risk.

The following remarks from Fed Chairman Bernanke (2011) clearly express the M preference for (AM', AF'): '*I have advocated that the negotiations about the budget focus on the longer term ... in light of the weakness of the recovery, it would be best not to have sudden and sharp fiscal consolidation in the near term. That doesn't do so much for the long-run budget situation, it's a negative for growth.*'

The latter two assumptions provide a link between the short-term and long-term horizons by postulating that cyclical stabilization actions affect the outcomes of the policies, which in turn affect future options and choices. Importantly, the reverse is also true: the Normal times preferences affect the policy responses to cyclical disturbances. It should however be emphasized that our main findings are largely independent of these assumptions. We discuss below the fact that they remain valid even if we assume that the policymakers prefer to stabilize the adverse shock themselves, for example because they want to be seen as 'doing something', or simply believe that their policy is more effective in addressing the economic weakness.[16] These five assumptions of the Downturn scenario imply the Battle of the Sexes game in which

(4) $$b' > c' > \max\{a', d'\} \quad \text{and} \quad y' > x' > \max\{w', z'\}.$$

We will formalize these assumptions in the simplest possible way by including two perceived costs (common across the policymakers): an *over-stimulating cost* C associated with the joint-stimulus outcome (PM', AF'), and a *deflation cost* D associated with the no-stimulus outcome (AM', PF'). Formally, we assume

(5) $$a' = a - D, b' = b, c' = c, d' = d - C, w' = w - D, x' = x, y' = y, z' = z - C.$$

It is straightforward to see that the Battle of the Sexes game (4) occurs if the two costs are sufficiently large

(6) $$C > \min\{d - c, z - x\} \quad \text{and} \quad D > \min\{a - c, w - x\}.$$

The following payoff matrix offers a specific example using the same underlying parameter values as in the Normal times payoff matrix (3), and $C = 5, D = 9$:

(7)

		F	
		PF'	AF'
M	AM'	deflation $-9, -12$	recovery $\mathbf{-4, -4}$
	PM'	recovery $\mathbf{-4.05, -3.25}$	over-stimulating $-8.8, -5$

Battle of the Sexes

Using the modelling short-cut through C and D rather than a fully articulated stochastic macro model has the advantage of a transparent link between the Normal times and Downturn scenarios. Even more importantly, it enables us to separate the effect of our stochastic timing from the effect of a stochastically evolving state as examined in 'stochastic games', see Shapley (1953).

[16]This alternative assumption seems more relevant at the very start of an economic contraction rather than its aftermath we focus on.

2.3. **Equilibria Using Standard Timing Setups.** A large body of the policy interactions literature (selected papers are cited in footnote 7) features both a coordination problem and a policy conflict, and hence points to the Game of Chicken and the Battle of the Sexes. While the former is an anti-coordination game and the latter a coordination game, they are similar. Both have two Pareto-efficient pure strategy Nash equilibria, each preferred by a different player, and one mixed strategy Nash that is Pareto-inferior to both pure Nash for both players. Both scenarios therefore feature a coordination problem as well as a policy conflict. In a nutshell, these are implied by the divergent preferences of M and F policy, which are in turn implied by the existence of a F gap.

What is the solution of these games? Under simultaneous moves, neither standard nor evolutionary game theory provide a way of selecting between the pure Nash equilibria in the Game of Chicken and the Battle of the Sexes due to the symmetry. The Pareto-inferior mixed Nash with regime switching is therefore a possibility, and a reason for concern.[17] To offer some resolution a common solution has been to apply Stackelberg leadership. Most famously, Sargent and Wallace (1981) focus on the case of the government being the Stackelberg leader in the Normal Times situation, and the central bank the follower. This gives the government an upper hand and enables it to achieve its preferred long-term policy regime by forcing a M solution to the F gap. In the alternative case of M-dominance the opposite is true and the unpleasant M arithmetic is avoided. The next section generalizes the Stackelberg leadership concept from static to dynamic, and shows that these conventional findings are refined or qualified.

3. Generalized Timing of Moves

Macroeconomic setups have commonly been studied using a one-shot game, or its repeated analog. In both of these settings players' moves are always simultaneous, which is arguably unrealistic in the macroeconomic policy context.[18] In order to relax such synchronicity assumption and allow us to incorporate institutional characteristics we will generalize the timing as follows:

(1) Expecting the Downturn and Normal times scenarios with probability p and $1-p$ respectively, the players move simultaneously at time $t = 0$.
(2) One of the players, called *reviser*, can move again in time $t \geq 0$ with some (ex-ante known) positive probability. The player does so using p and observing the initial play of the opponent, called the *leader*, who has to stick to his initial choice to the end of the dynamic stage game (normalized to $t = 1$).
(3) Payoffs accrue continuously over $t \in [0, 1]$.[19]

[17] There exists evidence of regime switching in the United States. Davig and Leeper's (2010) paper shows over a dozen regime switches in the U.S. since 1950, with all four our Normal times policy regimes present. We later show that uncertainties about the business cycle and/or the government's preferences greatly magnify the reasons for concern by making the inferior uncoordinated policy regimes more likely.

[18] It should be noted that most existing micro-founded macroeconomic models implicitly assume a simultaneous move since the two policies can be adjusted every period.

[19] In Basov, Libich, and Stehlík (2011) we allow *both* players to revise their initial actions on $t \in [0, 1]$. While the solution of the game is much more complex, the intuition is similar because what matters is the players' *relative* inability to revise actions. Let us also note that while the dynamic stage game can be repeated, we do not do so since our focus is on deriving circumstances under which the dynamic stage game itself has a unique and efficient subgame perfect equilibrium. In such case repetition does

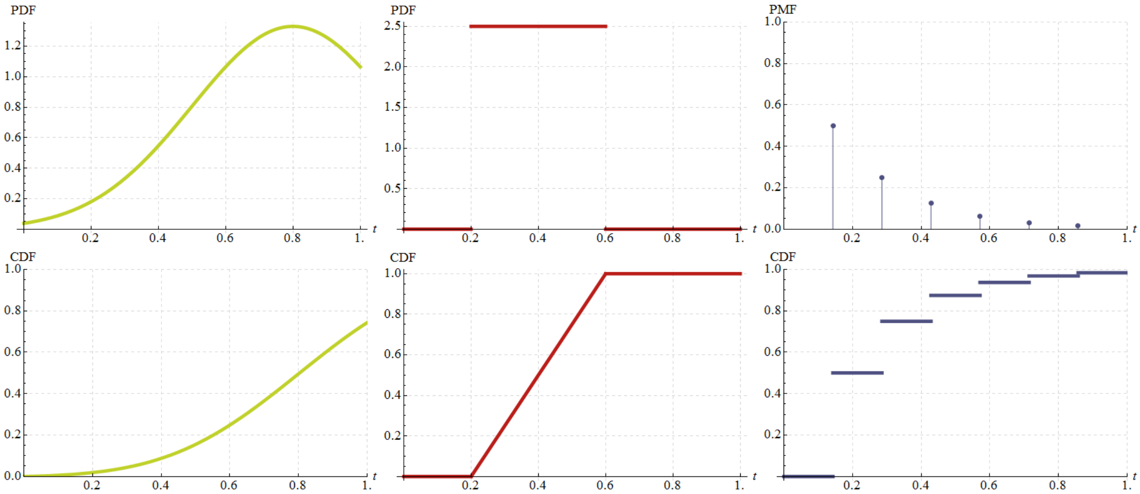

FIGURE 1. Three examples of timing: (truncated) normal, uniform, and binomial distributions, and the corresponding CDFs.

Our framework allows for an arbitrary timing of the revision opportunity. The top panels of Figure 1 offer three examples: normal, uniform, and binomial distributions, the latter in line with the popular Calvo (1983) scheme.[20]

Section 5 relates real world institutional characteristics to this timing. It implies that (only) in countries with a large F gap and low M commitment the last column of Figure 1 can be interpreted as the government being able to reconsider its F stance once a year in the proposed budget, whereas the central bank's board being able to reconsider its M stance every 4-6 weeks at its regular meeting. In contrast, if the F gap is small and M commitment explicitly legislated M is the likely leader in the game.[21] The following definition describes several related concepts used in our analysis.

Definition 1. *(i) The cumulative distribution function (CDF) summarizes the probability that by time t the reviser has had a revision opportunity (see the bottom panels of Figure 1). We call it the* ***revision function****, and denote it by $R_i(t)$, where $i \in \{M, F\}$ is the reviser.*
(ii) Based on i's ***revision speed*** *we will distinguish three cases:*

$$\int_0^1 R_i(t)\mathrm{d}t \begin{cases} = 1 & \textit{(standard) } \textbf{\textit{static leadership}}, \\ \in (0,1) & \textbf{\textit{dynamic leadership}}, \\ = 0 & \textit{(standard) } \textbf{\textit{simultaneous move}}. \end{cases} \tag{8}$$

not alter the outcomes. Nevertheless, allowing for reputation building would have the standard effects of possibly improving coordination and reducing the probability of inferior outcomes, see Mailath and Samuelson (2006).

[20] Libich and Stehlík (2011) offer a detailed mathematical treatment of several specific distributions, including combinations of CDFs.

[21] For example, the Policy Target Agreement in New Zealand specifies that the inflation target can only be altered when a new government or central bank Governor take office, ie roughly every 3-4 years.

(iii) The reciprocal of the complementary CDF,

$$\frac{1}{\int_0^1 (1 - R_i(t))\,\mathrm{d}t} \in [1, \infty],$$

expresses the degree of the leader's ***commitment*** *or* ***rigidity*** *- relative to reviser i.*[22]

The setup makes clear that the standard frameworks are two extreme cases, which may call in question the robustness of the conventional results.

4. Results

In order to better highlight the effect of dynamic leadership representing our institutional factors (M commitment and F rigidity), we contrast them with the standard simultaneous move game and the static leadership.

4.1. **Simultaneous Moves.** This is our special case $\int_0^1 R_i(t)\mathrm{d}t = 0$. The players' payoff from each regime is a weighted average of those in Downturn and Normal times with p as the weight, eg $a'' = (1-p)\,a + pa'$. Using (5) yields

(9)

		F	
		PF	AF
M	AM	$a'' = a - pD, w'' = w - pD$	$b'' = b, x'' = x$
	PM	$c'' = c, y'' = y$	$d'' = d - pC, z'' = z - pC$

It is apparent that even if (2), (4) and (6) hold, ie the underlying games are known to be the Game of Chicken and the Battle of the Sexes, under incomplete information we may have any class of game in (9). The ranking of the regimes by each policymaker depends on the exact values of C, D, and p, and there exists values under which any of the possible ranking obtains. Hence there is a large number of possible (Bayesian Nash) equilibria.[23] We can therefore conclude that:

Remark 1. *Uncertainties about the business cycle and/or about the deflation/overheating costs compound the coordination problem between M and F policy. This highlights the importance of aligning the objectives of the policymakers, and of effective communication between them to minimize the occurrence of Pareto-inferior regimes.*

4.2. **Static Leadership.** This can be represented by the case $\int_0^1 R_i(t)\mathrm{d}t = 1$. We are interested in deriving the circumstances under which one policy fully dominates, ie the dynamic stage game has a *unique* subgame perfect equilibrium payoff preferred by that policy.[24] As implied by (2) and (4), these preferred payoffs are delivered by $(AM', AM; AF', AF', PF, PF)$ for M, and by $(PM', PM', PM, PM; PF', AF)$ for F.

[22] Naturally, we have $\int_0^1 (1 - R_i(t))\,\mathrm{d}t = 1 - \int_0^1 R_i(t)\mathrm{d}t$.

[23] For example, if $D > \frac{a-c}{p}$ then $a'' < c''$, whereas if $D \in \left(a - c, \frac{a-c}{p}\right)$ then $a'' > c''$, and similarly for all relevant pairs of payoffs. Such ambiguity is further exacerbated if each policymaker has a different estimate of C, D, and p, which is likely to be the case in the real world.

[24] Obviously, the reviser can never fully dominate the game.

Proposition 1. *(i) (F-**dominance**) Under static F leadership, inflationary F spillovers onto M policy occur under **all** circumstances in the long-term, ie for any p and any payoffs satisfying (2) and (4).*
*(ii) (M-**dominance**) Under static M leadership, inflationary F spillovers onto M policy occur under **no** circumstances in the long-term.*
*(iii) Under static leadership, deflation occurs under **no** circumstances in the short-term.*

The long-term part of the proposition is in line with Sargent and Wallace (1981) in which leadership is an advantage that allows to force the opponent into compliance. The intuition of the short-run game is analogous: the leader can induce the reviser to attend to the temporary economic weakness.

4.3. **Dynamic Leadership.** This section shows that while the intuition of Proposition 1 still applies the results are not robust. It will become apparent that static leadership may provide misleading predictions, eg they down-play the possibility of deflation arising from a policy mis-coordination.

Proposition 2. *(i) (F-**dominance**) Under dynamic F leadership, inflationary F spillovers onto M policy **surely occur** if and only if F rigidity is **sufficiently high** relative to long-term M commitment,*

$$\frac{1}{\int_0^1 (1-R_M(t))\,\mathrm{d}t} > T_M = \frac{\overbrace{p\left(y'-w'\right)+(1-p)(z-x)}^{F\text{'s weighted conflict costs}}}{\underbrace{p\left(y'-x'\right)+(1-p)(z-w)}_{F\text{'s weighted victory gains}}} \in (1,\infty)\,. \tag{10}$$

*(ii) (M-**dominance**) Under dynamic M leadership, inflationary F spillovers onto M policy **surely do not occur** if and only if F rigidity is **sufficiently low** relative to long-term M commitment,*

$$\frac{1}{\int_0^1 (1-R_F(t))\,\mathrm{d}t} > T_F = \frac{\overbrace{p\left(b'-a'\right)+(1-p)(a-b)}^{M\text{'s weighted conflict costs}}}{\underbrace{p\left(b'-c'\right)+(1-p)(a-d)}_{M\text{'s weighted victory gains}}} \in (1,\infty)\,. \tag{11}$$

*(iii) **(Regime switching)** If neither of the two conditions hold then inflationary F spillovers onto M policy **may or may not occur** in the long-run. Furthermore, **deflation may occur** in the short-run, unlike in cases (i)-(ii), and unlike under static leadership. Paradoxically, more deflation averse policymakers are more likely to experience deflation since T_M and T_F are increasing in D.*

Proof. Appendix B presents the proof. It also expresses the thresholds T_M and T_F as functions of the underlying parameters of the macroeconomic setup. This shows that T_M is decreasing in the government's aversion to reneging on promised net transfers relative to real debt variability, δ_F, and that T_F is decreasing in the central bank's conservatism ϕ_M. It further shows, in line with the last statement of claim (iii), that a higher deflation cost D increases both T_M and T_F and thus enlarges the Regime switching region.

To demonstrate the intuition consider the special case $p = 1$, in which F is the leader - relevant to claim (i). Solving backwards, player F knows that through her own inaction she can force M policy to expand the economy when the bank's revision opportunity arrives. This rewards F for pursuing his preferred outcome $(PM', PM'; PF')$. Nevertheless, as the initial waiting game is costly - potentially leading to a deflation - the government's victory reward has to more than compensate this initial cost. Formally, for F to dominate the game PF' must be the unique best response not only to the simultaneously played PM', but also to AM', ie it must hold that

$$\underbrace{w' \int_0^1 (1 - R_M(t))\,\mathrm{d}t}_{(AM',PF')\text{: policy conflict}} + \underbrace{y' \int_0^1 R_M(t)\mathrm{d}t}_{(PM',PF')\text{: } F \text{ victory}} > \underbrace{x'}_{(AM',PF')\text{: } F \text{ surrender}}.$$

Rearranging this yields the following condition

$$\frac{1}{\int_0^1 (1 - R_M(t))\,\mathrm{d}t} > T_M = \frac{\overbrace{(y' - w')}^{F\text{'s conflict cost}}}{\underbrace{(y' - x')}_{F\text{'s victory gain}}},$$

which is the special case of (10) under $p = 1$. If satisfied, M will surrender from the start and there is in fact no conflict in equilibrium. The government's threat of inaction becomes credible, and forces the central bank into stimulatory action, which prevents deflation. Formally, the area below the CDF, $\int_0^1 R_M(t)\mathrm{d}t$, over which F's victory gain accrues is sufficiently large relative to the conflict cost area above the CDF, $\int_0^1 (1 - R_M(t))\,\mathrm{d}t$. Put differently, M policy is expected to be able to revise quickly which implies a small potential cost to the government from the conflict.

It should by now be apparent that if M is the leader, the case of claim (ii), the T_F threshold is just a mirror image of T_M. The intuition is simply reversed: it is now M who is willing to undergo a costly conflict with F, and induce her to expand the economy. □

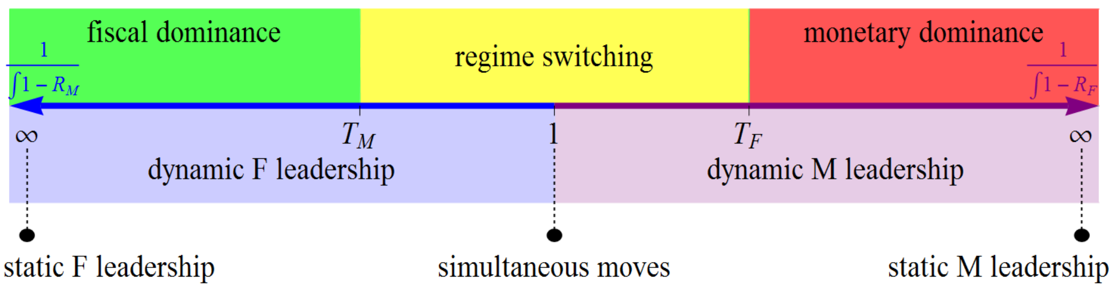

Figure 2. The top part shows the $\frac{M\text{-commitment}}{F\text{-rigidity}}$ space under dynamic leadership including the thresholds T_i separating the three equilibrium regions. The bottom part shows the relationship to the standard timing.

The dynamic leadership results are graphically depicted in the upper part of Figure 2. Let us discuss the game theoretic insights of our results (their real world interpretation and discussion appears in the next section). They refine the results obtained under the simultaneous move and static leadership in the bottom part of Figure 2.

First, they show that the leader may not always dominate: its commitment/rigidity may be insufficiently strong, in the interval $\frac{1}{\int_0^1 (1-R_i(t))\mathrm{d}t} \in (1, T_i)$. In fact, under some circumstances the Regime switching region may be much larger than the two dominance regions. Second, they identify several variables that determine the required degree of commitment/rigidity for a policy to fully dominate. In particular, the thresholds T_F and T_M in (10)-(11) are increasing functions of the leader's conflict costs relative to his victory gain - in Downturn and Normal times weighted by the probability p. Third, they show how uncertainty about the business cycle and the potential costs of deflation may play a role in the effectiveness of institutional design features such as an explicit inflation target. Specifically, if the cost/gain in Downturn exceeds that in Normal times then both T_F and T_M are increasing in p. Then a higher p reduces the range of parameters over which the socially optimal outcomes occur, eg deflation becomes more likely. These messages different from those obtained by static leadership.

It is straightforward to see that under the alternative assumption of the dominant policymaker preferring to respond to the underlying adverse shock himself in the Downturn scenario the intuition is unchanged. In such case, if (10)-(11) hold then the dominant policymaker has the power to force the dominated one *not* to respond to the shock. The only difference is the form of the potential policy conflict. The tug-of-war would no longer be a waiting game with neither policy responding, but one with both policies responding aggressively in attempt to force the opponent to cease their stimulus.

5. Relating the Analysis and Results to the Real World

Table 1 summarizes the occurrence of short-term deflation and long-term high inflation in the three identified regions. In which of these equilibrium regions are real world economies located? How do changes in the policies' institutional design affect their transitions across the regions? Answering these questions is essential for predicting macroeconomic outcomes and formulating policy recommendations.

Equilibrium region	The M commitment / F rigidity ratio	Deflation in the Downturn equilibrium	High inflation in the Normal times equilibrium
Fiscal dominance	low	no	yes
Regime switching	intermediate	probability increasing in $\int_0^1 (1 - R_i(t))\, dt$ for $i \in \{M, F\}$	probability increasing in $\int_0^1 R_M(t)dt$ and $\int_0^1 (1 - R_F(t))\, dt$
Monetary dominance	high	no	no

Table 1. Equilibrium regions and monetary outcomes.

5.1. **Interpretation of the Revision Probabilities.** Let us start by giving a real world interpretation to our two key institutional concepts related to the players' inability to revise their previous stance: F rigidity and long-term M commitment. Arguably, both relate to constraints placed on the policies by past/present legislation.

The degree of F rigidity naturally increases in the size of the F gap, which in turn is determined by legislation relating to mandatory expenditures (eg health, social security, and welfare), taxes (eg promised tax cuts), as well as the extent of debt servicing. The greater the shortfall between mandatory future government expenditures and taxes, the harder it may be for the government to implement reforms towards sustainability.

Similarly, the degree of long-term M commitment depends on the extent to which the commitment to price stability is grounded in the central bank legislation/statutes, and the related accountability provisions. Arguably, it is increased when a numerical target for average inflation is legislated. This is because such a transparent objective cannot be easily reconsidered - due to political, institutional, and reputational constraints.[25]

5.2. **Quantifying F Rigidity and Long-term M Commitment.** In order to attempt to assign real world countries to the three equilibrium regions this section offers a way of quantifying the $\frac{M \text{ commitment}}{F \text{ rigidity}}$ ratio. We develop an index of both institutional variables based on established indices in the literature. To ensure robustness we average over a number of existing measures.

In terms of F rigidity, our index is an average of eight components based on: (i) the F space concept of Aizenman and Jinjarak (2011), (ii) the estimated probabilities of a given F space by Ostry el al. (2010), (iii) the F space, F path, and F governance of Augustine el al. (2011), and (iv) average F balances over 2000-11. For details see Table 2 in Appendix C. In terms of long-term M commitment, we use four components based on: (i) the political transparency measure of Eijffinger and Geraats (2006) as calculated by Dincer and Eichengreen (2011), and (ii) the final responsibility measure of the central bank accountability index of Haan et al. (1998) as updated by Sousa (2002), and (iii) the inflation focus and central bank accountability measures of Fry et al. (2000).[26] For details see Table 3.

Appendix C also reports the original data (Table 4), and discusses how we adjust for different units and mean levels of these measures in order to show not only the institutional ranking of countries, but also maintain the quantitative nature of the underlying measures. Figure 3 presents our F rigidity scores (from Table 6) for the 25 countries for which at least 5 out of the 8 measures have been calculated in the underlying papers. It is interesting to note the large differences that exist across countries.

[25]The New Zealand Policy Target Agreement is a good example of such constraints. It implies that changes to the legislated inflation target can only be done infrequently (at pre-specified occasions when the Governor or government change), and that the Governor of the central bank is personally accountable for achieving the target.

[26]We have also considered the monetary commitment index by Freytag (2001) but do not use it because of its broad focus (it also includes criteria regarding central bank independence, bank supervision, exchange rate, and currency convertibility). For the relationship between inflation targeting, transparency, and accountability see eg Walsh (2003).

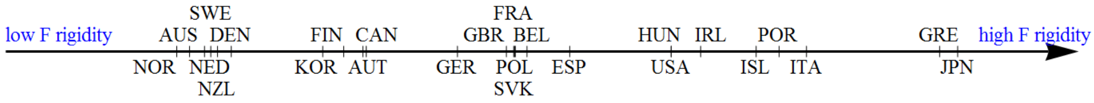

FIGURE 3. Relative fiscal rigidity scores from Table 6.

Figures 4 and 5 offer the $\frac{M \text{ commitment}}{F \text{ rigidity}}$ space and ratios for a subsample of countries that have an autonomous M policy (ie neither use nor are pegged to the Euro - for reasons apparent in Section 6).

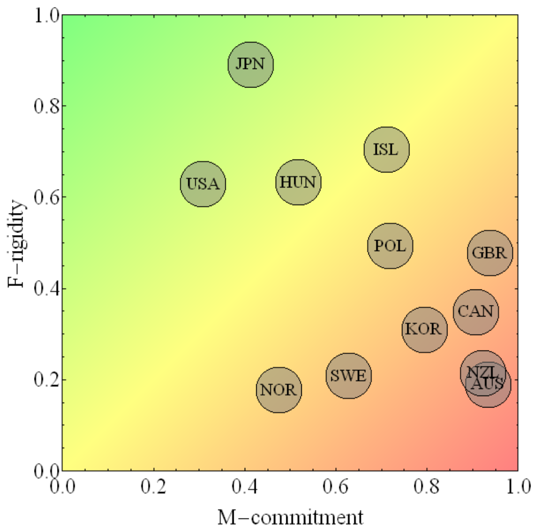

FIGURE 4. The monetary commitment vs fiscal rigidity space.

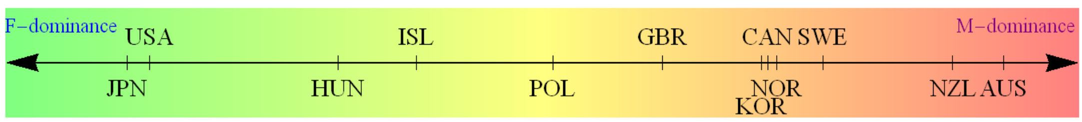

FIGURE 5. Relative monetary commitment to fiscal rigidity scores ratios.

5.3. **Countries and the Equilibrium Regions.** While the ranking of countries in the $\frac{M\text{-commitment}}{F\text{-rigidity}}$ space presented in Figure 5 can be done with some degree of confidence (for a given point in time), assigning countries to our three equilibrium regions - ie identifying the thresholds T_M and T_F is more problematic. As our results show, these are a function of a number of (hard to quantify) variables. Such uncertainty is indicated in Figures 4 and 5 by the fact that the transition between the colours is gradual - in contrast to that of Figure 2. Keeping that in mind, we will discuss observed developments and outcomes as well as the related empirical literature. In doing so we will focus on two advanced countries from opposite sides of the $\frac{M\text{-commitment}}{F\text{-rigidity}}$ space: the United States and Australia.

5.3.1. *The United States.* Davig and Leeper (2010) show while the Ricardian regime occurred during 1984-1991 and again during 1995-2001, the non-Ricardian regime (PM, AF) has prevailed since 2002. This is consistent with Li, Li, and Yu (2011) whose estimates suggest that the Fed has not been adhering to the Taylor Principle since the early 2000s.

In terms of the Downturn scenario, Economist (2011) reports that between mid-November 2010 and end-March 2011 '*America's Treasury has issued some $589 billion in extra long-term debt, of which the Fed has bought $514 billion*'. The Economist concludes: '*In effect, QE ... has been undermined by debt-management policy*'. This implies (PM', PF') in our setting with M policy carrying out the required stimulus.

Such observed combination of the (PM', PF') and (PM, AF) regimes can, in equilibrium, occur with certainty in the F-dominance region, and with positive probability in the Regime switching region. Nevertheless, neither regime can occur in the M-dominance region, implying that the T_F threshold in Figure 5 is to the right of the US.

While any such predictions must be made with a great amount of caution, at face value these outcomes would suggest both a positive probability of short-term deflation, and a (possibly much larger) probability of long-term high inflation in the U.S. in the absence of structural and institutional policy changes.[27] This is further highlighted by the political dead-lock evident during the July 2011 debt ceiling negotiations. As a consequence, Feldstein (2012) discusses the Fed's exit strategy based on paying (sufficiently high) interest on banks' excess reserves, and concludes: *'It will take skill – as well as political courage – for the Fed to avoid the rise in inflation that the existing liquidity has created'.*

5.3.2. *Australia.* Australia serves as an opposite example. We saw an increase in the cash rate by the Reserve Bank of Australia just seventeen days before the November 2007 Federal election (at a time when other central banks were already reducing their rates). Since the mid-1990s both major Australian parties have been firmly focused on F discipline which has resulted in virtually zero public debt prior to the GFC. There has only been a small increase in debt since due to the implementation of F stimulus packages - that were in 2009 larger than those in the U.S.[28]

These developments suggest a combination of the (AM', AF') and (AM, PF) regimes, which can, in equilibrium, occur with certainty in the M-dominance region, and with some positive probability in the Regime switching region. Nevertheless, neither regime can occur in the F-dominance region. Thus the T_M threshold in Figure 5 is to the left of Australia implying (all else equal) that both short-term deflation and long-term excessive inflation are less likely than in the United States.

5.4. **Policy Implications.** Our analysis has several policy implications. First, it implies that it is desirable for countries to ensure the M-dominance region in which both deflation and high inflation are surely avoided in equilibrium. To achieve this over the full course of the business cycle, ie for all values of $p \in [0, 1]$, the $\frac{M\text{-commitment}}{F\text{-rigidity}}$ ratio needs to be sufficiently high. Put differently, institutional design of both policies matters. Naturally, this ratio can be increased either through higher M commitment (eg

[27]Strikingly, the implied probability of future inflationary outcomes is higher than that of Iceland.

[28]Aizeman and Jinjarak (2011) report the 2009 stimuli to be 2.7% of GDP in Australia and 1.8% of GDP in the U.S.

legislating a numerical inflation target and accountability provisions) or through lower F rigidity (eg structural F reform).

Second, our analysis shows that the implied policy prescription is more nuanced than just 'increase M commitment and/or decrease F rigidity'. Proposition 2 implies that a higher $\frac{M\text{-commitment}}{F\text{-rigidity}}$ ratio unambiguously improves outcomes *if and only if* it moves the economy to the M-dominance region. Paradoxically, an increase in M commitment and/or a decrease in F rigidity that are insufficiently large may lead to Pareto inferior outcomes. If they move the economy from the F-dominance region only to the Regime switching region, there may be no improvement in the Normal times outcomes (high inflation can still occur) and worsening of the Downturn outcomes (deflation now becomes a possibility). This important policy warning cannot be obtained from the static Stackelberg leadership framework in which the Regime switching region does not exist.

It remains an open question whether the January 2012 move of the FOMC attempting to increase the degree of the Fed's long-term M commitment by announcing its 2% inflation target may be a case in point. While making the target more explicit, it falls short of the degree of M commitment delivered when such an inflation target is legislated.

Third, modelling jointly the short-term and long-term horizons sheds different light on the two main F policy prescriptions during 2010-2011, namely 'We need more stimulus to boost the economy' versus 'We need more austerity to stop rising debt'. Our analysis implies that these two recommendations may *not* be contradictory.

Our results indicate that if the probability of the Downturn scenario is high we need a *combination* of AF' and PF implemented jointly. In words, it is a credible structural F reform that eliminates the expected F gap, which in turn reduces the concerns of a F crisis, and hence enables the government to stimulate the economy in the short-term through both conventional measures (such as infrastructure spending) and unconventional measures (issuing more short-term debt). This conclusion is in line with Leeper (2011).

5.5. **Empirical Support.** Our results are generally consistent with observed developments and existing empirical evidence. First, the fact that the magnitudes of the variables affecting the T_F and T_M thresholds differ across countries implies likely differences in institutional design of both policies. For example, consider the identified substitutability of explicit inflation targeting and the central bank's conservatism implied by T_F decreasing in ϕ_M. It offers a possible explanation for why in the early 1990s countries with a high degree of central bank independence/conservatism such as Germany, Switzerland, and the United States did not legislate a numerical target for average inflation, whereas most others such as Canada, the United Kingdom, or Australia did.

Second, our result that a committed central bank is more likely to enter in a tug-of-war with the government is supported by the estimates of Franta et al (2012). Using time varying parameter VARs, it is shown that the degree of M policy accommodation of debt-financed government spending shocks generally decreased in the latter group post adoption of an explicit inflation target (or accommodation changed to offsetting such shocks by raising interest rates). In contrast, the degree of M accommodation has not changed or increased in the group of non-targeters over the same period. Figure 6 offers a sample of the results.

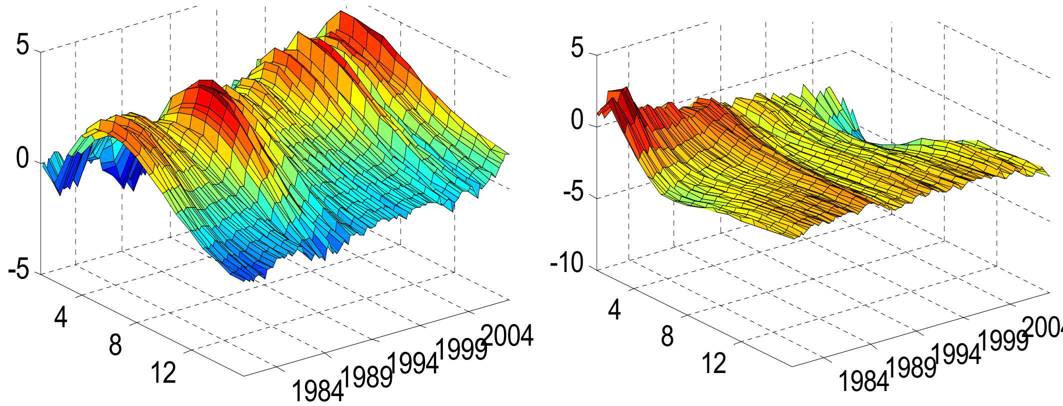

Figure 6. Impulse responses of the interest rate (vertical axis) to a debt-financed government spending shock in Australia (left) and the U.S. (right), for details see Franta, Libich and Stehlík (2012).

Third, the identified disciplining effect of M commitment on F policy may explain an additional result of Franta et al (2012) that in all early inflation targeters F outcomes started improving 1-3 years after the adoption of the regime. In contrast, F outcomes have not changed or worsened in major non-targeters over this period. Our results indicate this also: the correlation coefficient between F rigidity and M commitment scores is -0.51 (see Figure 4 with the early inflation targeters in the top left corner).[29]

This is further consistent with the arguments of Brash (2011a), the former Governor of the Reserve Bank of New Zealand: *'I have not the slightest doubt that having legislation which requires government and central bank to formally agree, and disclose to the public, the inflation rate which the central bank must target has a most useful role in creating strong incentives for good fiscal policy.'* The author offers several real world examples of how this has occurred [for more discussion see Brash (2011b)].

6. An Extension: a Monetary Union

6.1. Three Types of Governments.

Three Types of Governments. Our benchmark setup focused on the frequently studied case of a responsible central bank facing an *ambitious* government, F^A. This section introduces two additional types of government: *responsible*, F^R, and *ultra-ambitious*, F^U. We do so in the context of a monetary union with a common central bank headed by a responsible governor as in our benchmark specification.[30] But it will be apparent that the analysis can also be interpreted as a single country setting in which the central bank has incomplete information about the type of government $i \in \{A, R, U\}$ it is facing.[31]

[29] It must however be emphasized that these results provide no evidence of causality. There could in principle be a third common factor responsible for both high M commitment and low F rigidity.

[30] For an analysis of monetary-fiscal interactions in a currency union see e.g. Kirsanova et al. (2007).

[31] The policy interaction thus features two layers of uncertainty: about economic conditions and the opponent's type. Both of them seem realistic in the post-GFC environment.

To allow the latter interpretation, and make the analysis illustrative we will focus on the case in which the timing of F moves is the same across the three types of governments. This seems natural as the principal opportunity of countries to change their F stance happens in the annual budget. Denote the proportion of the F^A, F^R and F^U types of government in the union by f^A, f^R and f^U respectively, where $f^A + f^R + f^U = 1$.[32] The overall payoff of the common central bank is an average of the payoffs from interactions with each government type i, using the weights f^i. The payoff of each government type is directly determined by its own stance and that of the common central bank.[33]

6.2. **Responsible F Policymaker.** A responsible government will be assumed to prefer the socially optimal outcomes, her payoff satisfying

$$w_R > y_R > z_R > x_R \text{ and } x'_R > z'_R > y'_R > w'_R.$$

Using the policy parameter values utilized in (3) and (7) with one change, we can achieve this by sufficiently increasing the government's aversion to reneging on promises in a Downturn, and by sufficiently decreasing it in Normal times.[34]

		F^R	
		PF	AF
M	AM	Ricardian $\mathbf{0,6}$	tug-of-war $-4,-4$
	PM	tug-of-war $-4.05, 2.75$	monetization/FTPL $-3.8, 0$

Normal times (responsible F)

		F^R	
		PF'	AF'
M	AM'	deflation $-9,-15$	recovery $\mathbf{-4,-4}$
	PM'	recovery $-4.05,-6.25$	over-stimulating $-8.8,-5$

Downturn (responsible F)

We have a symbiosis scenario of Dixit and Lambertini (2003) in both the Downturn and Normal times. This is because both games have a unique Pareto-efficient Nash equilibrium, consisting of the preferred outcome for both players and coinciding with the socially optimal outcome $(AM', AF'; AM, PF)$. This means that if all governments in the union are responsible (or, under the single country interpretation, the probability of a responsible government is unity), this outcome will obtain under all parameter values and any timing of moves (leadership). Put differently, deflation, over-stimulating, and inflationary F spillovers never occur even if the degree of M commitment is low.

6.3. **Ultra-ambitious F Policymakers.** We assume that ultra-ambitious governments are unwilling to coordinate with the central bank. This reflects a free-riding problem in a M union, present primarily in small member countries. Intuitively, the political benefits of excessive spending in an individual member country accrue predominantly to the indisciplined government itself, whereas the cost (negative externality) in terms of higher interest rates and risk is spread across all union members. Therefore, if a country only forms a small part of the union, and does not internalize this negative externality it

[32]These proportions can express the relative number of such countries, or can be weighted by their economic size - whichever is more relevant in the particular M union. In a single country interpretation, these proportions are the probabilities of the respective government's type as percieved by the central bank.

[33]Indirectly, the actions of other governments in a M union also have an impact since they determine the incentives of the common central bank, and hence the equilibrium outcomes.

[34]The matrices alter $\delta_F = 3$ in (21) to $\delta_F = 6$ in the Downturn and $\delta_F = -6$ in Normal times.

imposes on fellow members, it may be unwilling to change its excessive F stance even if the common central bank is known to be pursuing AM.[35] Formally, the payoffs satisfy:

$$z_U > x_U > w_U > y_U \text{ and } y'_U > w'_U > x'_U > z'_U.$$

Conversely to the case of a responsible F, we can achieve this by sufficiently decreasing the government's aversion to reneging on promises in a Downturn, and by sufficiently increasing it in Normal times.[36]

		F^U	
		PF	AF
M	AM	Ricardian $0, -6$	tug-of-war $-4, -4$
	PM	tug-of-war $-4.05, -6.25$	monetization/FTPL $\mathbf{-3.8, 0}$

Normal times (ultra-ambitious F)

		F^U	
		PF'	AF'
M	AM'	deflation $-9, -3$	recovery $-4, -4$
	PM'	recovery $\mathbf{-4.05, 5.75}$	over-stimulating $-8.8, -5$

Downturn (ultra-ambitious F)

Both games have a unique Pareto-efficient Nash equilibrium: (PM', PF') and (PM, AF). Nevertheless, these equilibria do *not* coincide with the central banker's preferred and socially optimal outcomes. This means that if all governments in the union are ultra-ambitious, deflation and over-stimulating never occur in the short-term regardless of the degree of M commitment. This is because the common central bank is induced to provide the required stimulus. Nevertheless, F spillovers occur with certainty, and this is true even if the central bank is infinitely strongly committed relative to F rigidity.[37]

6.4. **Results.** Our setup implies that the preferred subgame perfect equilibrium of F^R is the same as M's, whereas F^U shares his preferred equilibrium with F^A. We may therefore see the common central bank joining forces with the responsible governments to better deal with the 'coalition' of the (ultra) ambitious governments. The following, a generalization of Proposition 2, indicates which coalition dominates, if any.

Proposition 3. *(i)* ***(ambitious-coalition-dominance)*** *Inflationary F spillovers onto M policy surely occur if and only if (10) holds, for which a necessary condition is that the proportion of responsible governments in the union is sufficiently low*

$$f^R < \underline{f}^R = \frac{p(c' - a') + (1-p)(d-b)}{p(b' - d' + c' - a') + (1-p)(a - c + d - b)}. \tag{12}$$

Then and only then deflation is surely avoided under all types of government.
(ii) ***(responsible-coalition-dominance)*** *Inflationary F spillovers onto M policy surely*

[35]For a formal modelling of this free-riding in a M union see Libich, Savage and Stehlík (2010).

[36]The matrices alter $\delta_F = 3$ in (21) to $\delta_F = -6$ in the Downturn and $\delta_F = 6$ in Normal times.

[37]An ultra-ambitious government is more likely in a currency union not only because the common central bank cannot effectively punish mis-behaving governments, but also because financial markets tend to defer their punishment due to the possibility of bailout by fellow members.

do not occur if and only if the proportion of responsible governments in the union is sufficiently high

(13)

$$\frac{1}{\int_0^1 (1 - R_F(t))\,\mathrm{d}t} > T_F =$$

$$\frac{f^A\left[p(b' - a') + (1-p)(a-b)\right]}{f^A[p(b'-c') + (1-p)(a-d)] + f^R[p(b'-d') + (1-p)(a-c)] - f^U[p(c'-a') + (1-p)(d-b)]},$$

for which a necessary condition is

$$(14) \qquad f^R \geq \overline{f^R} = \frac{f^U[p(b'-a') + (1-p)(a-b)] - [p(b'-c') + (1-p)(a-d)]}{[p(c'-d') + (1-p)(d-c)]}.$$

If (13) then short-term deflation is avoided in countries with responsible and ambitious governments, but is surely occurs in countries with ultra-ambitious governments.
(iii) ***(Regime switching)*** *If neither (12) nor (13) hold then inflationary F spillovers onto M policy may or may not occur in the long-run. Furthermore, deflation may occur in the short-run under all types of governments.*

Proof. See Appendix D. □

The intuition of our benchmark dynamic leadership results carries over. What determines the outcomes is the degree of M commitment of the common central bank relative to the degrees of F rigidity of ambitious governments, as well as uncertainty and the policymakers' conflict costs and victory gains over the business cycle.

6.5. **Policy Insights.** An additional contribution of this section is to show how responsible governments potentially improve the outcomes, and ultra-ambitious governments (free-riding) make them worse. In particular, if countries with responsible governments make up a large enough part of the M union, then a strongly committed central bank is willing to undergo the conflict with the remaining ambitious and ultra-ambitious governments, with the support of the responsible government types. It knows that ambitious governments will comply in both the short-term and long-term, and hence the exit strategy will be successful. Nevertheless, the ultra-ambitious governments will not do so, which will in such countries lead to a double-dip recession/deflation in the short-term, and continued F excesses in the long-term. Obviously, this may mean a forced departure of such free-riding country from the M union.

If the M union is composed primarily of ultra-ambitious governments (or, in the single country interpretation, the central bank perceives the probability of the ultra-ambitious government type to be above a certain threshold), then even an infinitely strong M commitment may not ensure avoiding F inflation. Formally, if $f^R < \overline{f^R}\left(f^U\right)$ then the T_F threshold in (13) does not exist, and hence even if all types of government can revise their stance instantly, $\int_0^1 R_F(t)\mathrm{d}t = 1$, the conflict with the F^U types would be too costly for M. This means that in Figure 2 there would only be two rather than three equilibrium regions: the M-dominance region disappears.

It will be interesting to follow the developments in the European monetary union. As Figure 3 shows, F rigidity of most of its member countries (including the large ones) is fairly high. This, combined with the strong legal commitment of the European Central

Bank to price stability, points to the Regime switching region. In the Downturn scenario, this region implies a waiting game with the (AM', PF') regime featuring F austerity and no/little M stimulus, arguably a description of the 2011 Eurozone situation. Whether we will also see a severe double-dip recession and deflation, the possibility of which in the Regime switching region is positive, remains to be seen.

7. Summary and Conclusions

The post-GFC situation of continued economic weakness combined with dire long-term F projections has posed unprecedented challenges for policymakers. The paper attempts to provide some insights into the possible macroeconomic outcomes, and offer some policy recommendations - both in a single country and a currency union setting.

To do so we postulate a game theoretic framework with generalized timing of moves. This allows us to examine the *strategic* aspect of monetary-fiscal policy interactions, unaccounted for in standard macroeconomic models. Our analysis provides a link between the short-run (stabilization) considerations and long-run (sustainability) considerations under incomplete information about the business cycle conditions.

Allowing for stochastic revisions and asynchronous timing of actions enables us to postulate the concepts of long-term M commitment and F rigidity relating to the policies' inability to alter its previous stance. We show that the outcomes of the policy interaction, both short-term and long-term, depend on these institutional features as well as uncertainty, structural factors, and the central bank's and government's preferences. This is because all these variables affect the magnitude of a potential policy conflict in various phases of the business cycle, and hence the policymakers' payoffs.

In addition to the standard M-dominance and F-dominance equilibrium regions of Sargent and Wallace (1981), we identify an intermediate Regime switching region in which the intuition differs from conventional results. Most strikingly, deflation can occur in the aftermath of a Downturn, and in fact the more deflation averse policymakers are the more likely deflation is. This is because deflation aversion increases the probability of a tug-of-war between the central bank and the government.

These insights do not only apply to the unpleasant M arithmetic and FTPL literatures, but generally relate to any monetary-fiscal interaction paper that features a coordination problem and/or conflict between the policies (eg all the papers cited in footnote 7, despite their diverse modelling approaches).

In Section 5 we relate our findings to the real world. We first quantify the degrees of F rigidity and M commitment in selected countries, and then match them to the three equilibrium regions in order to hypothesize about the likely results of the policy interaction. It is shown that the U.S. are unlikely to be in the optimal M-dominance region, and hence the danger of both deflation in the short-term and high inflation in the long-term exists and should not be underestimated.

The section then offers some policy recommendations to ensure undesirable macroeconomic outcomes are avoided. While more research is required to provide definitive prescriptions for individual countries, the paper offers a general lesson: in uncertain times M policy may need to be committed very explicitly to a numerical target for average inflation to avoid F pressures and spillovers. Without a strong long-term M commitment, which serves as the policy's credibility insurance over the business cycle, the exit strategy of central banks from the extraordinary recent stimulatory actions may prove unsuccessful.

Interestingly, we show that such M commitment may not only improve the outcomes of M policy, but also discipline the government and lead to superior long-term F outcomes too. This is because it increases the chances of a M leadership which reduces the payoffs and incentives of governments from avoiding required F reforms. Let us mention that our long-term M commitment concept is compatible with the timeless perspective pre-commitment of Woodford (1999) or quasi-commitment of Schaumburg and Tambalotti (2007). This is because it does not prescribe (a rule for) *how* actions need to be dynamically changed in response to disturbances, it only restricts the frequency with which the policy stance can be altered. This implies that an explicit numerical target for average inflation does not necessarily reduce the policy's flexibility to respond to shocks: for formal modelling of this see Libich (2011). As Brash (2011a) reflects on his experience as central bank Governor: *'An inflation target is only a strait jacket if it is badly designed. All those with which I'm familiar allow for monetary policy to respond flexibly and predictably to exogenous shocks...'*

Section 6 extends the analysis to the case of a currency union, and shows that the F disciplining through M commitment may be ineffective against some (ultra-ambitious) types of governments. These are more likely to appear in a M union due to incentives for free-riding of (especially small) member countries. This may explain the fact that despite the European Central Bank's explicit inflation commitment F outcomes have generally been unsatisfactory. Therefore, in such countries politicians' incentives need to be altered directly by implementing transparent and enforceable F rules. The fact that only a handful of countries have implemented these suggests that the political reality of such an institutional reform may be difficult. The outcomes in Europe teach us that even if legislated, such arrangements may lack traction - especially in a M union.

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Appendix A. The Macroeconomic Intuition of the Normal Times Scenario

A.1. **Real World Fiscal Stress.** The 2011 Global Risks Barometer by the World Economic Forum highlights the consensus on the gravity of the fiscal problem. It evaluates the main risks facing the world based on responses from over 500 experts and decision-makers. Out of the 37 economic, geopolitical, societal, environmental and technological risks, 'fiscal crises' are the number one risk in terms of the perceived financial losses, and they are perceived as 'very likely to occur in the next ten years'.

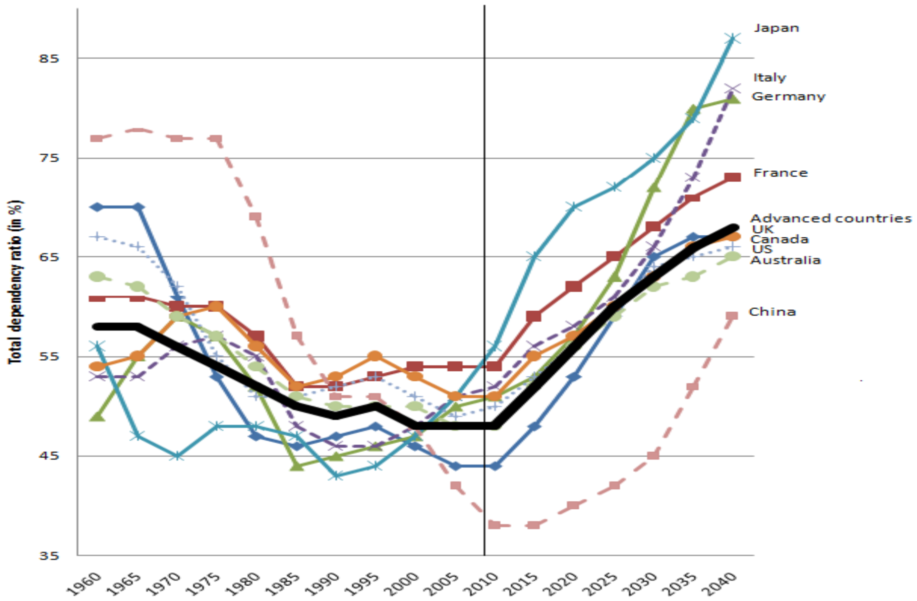

FIGURE 7. Total dependency ratio (population aged 0-14 or 65+ over population aged 15-64) in selected countries, and the mean for advanced (developed) countries. United Nations (World Population Prospects) data, 1960-2010 actual, 2011-2040 forecast.

It should be stressed that the implemented post 2008 fiscal stimuli only form a small part of the observed fiscal stress facing advanced countries. For example, IMF (2009) estimate that in G20 countries the average contribution of the GFC to the long-term fiscal imbalance is only 10.8% of the contribution of aging populations related factors. Specifically, the paper reports the net present value of the impact of aging-related spending on F deficits in the order of hundreds of percent of GDP for virtually all advanced countries. Even in the United States, where these demographic factors are less unfavourable than the average of advanced economies (and in any other G7 country), Batini, Callegari, and Guerreiro (2011) estimate that: *'a full elimination of the fiscal and generational imbalances would require all taxes to go up and all transfers to be cut immediately and permanently by 35 percent.'*[38]

For illustration of the demographic driving forces United Nations data can be used. They show that between 1960 and 2040 the old-age dependency ratio in advanced economies is predicted to more than triple on average, with most of the rise yet to come. This implies dramatic increases in pensioner/worker and total dependency ratios: for the latter see Figure 7. In fact, this does not reveal the full extent of the problem. As Bongaarts (2004) reports, the actual pensioner per worker ratio in advanced economies is commonly 50-100% higher than the old-age dependency ratio.[39]

[38]See also Neck and Sturm (2008).

[39]As an aside, the fact that both advanced and emerging countries such as China face aging populations implies that the 'global saving glut' situation of the early 2000s is going to get dramatically reversed, with 'interesting' implications for capital markets.

A.2. **Modelling Fiscal Stress.** Our exposition of intertemporal problems draws on Leeper and Walker (2011). In order to better highlight the key issues regarding F stress - that are of a long-term nature - we will suppress the dynamics and consider two periods only: period 0 represents the past, and period 1 represents the future[40]

$$R_1 B_1 - \lambda \frac{Z_1 - T_1}{P_1} = R_0 B_0, \tag{15}$$

where B is the stock of bonds, R is the applicable gross nominal interest rate, and P_1 is the future price level. $Z_1 - T_1$ is the level of *future net transfers* (transfers Z_1 minus taxes T_1) *promised* to the households by the existing legislation - in nominal terms ('dollars'). In contrast, $\lambda (Z_1 - T_1)$ is the *actual* (delivered) level of future net transfers. This implies that $(1 - \lambda_t) \in [0, 1]$ can be interpreted as a *reneging* parameter, and that $\frac{\lambda(Z_1 - T_1)}{P_1}$ expresses the delivered net transfers in real terms ('goods').

Intuitively, existing debt including interest payments must be paid for by future primary surpluses or by issuing new bonds. Further, promised net transfers can be reneged upon by the government, or their real value inflated away by the central bank. We can discuss the two main *sources* of F stress using (15):

1. **Past fiscal excesses** or **bank bailouts** (eg Greece and Ireland respectively): high B_0, usually also associated with high R_0 due to a risk premium.
2. **Future demographic trends (aging population)**: $Z_1 > T_1$.

In order to streamline the analysis and focus on advanced economies we will follow Leeper and Walker (2011) and highlight the latter source of F stress. They do so by postulating the promised transfers variable Z_1 as an exogenous AR(1) process - possibly divorced from T_1 and hence from the sustainable path. Since our budget constraint (15) abstracts from the dynamics of debt we can simply incorporate a fiscal gap by imposing

$$Z_1 - T_1 > 0. \tag{16}$$

What are the possible *solutions* to this gap? They can be summarized as follows:

1. **Structural fiscal reform**: reducing Z_1 and/or increasing T_1 to ensure the required level of $Z_1 - T_1 \leq 0$.
2. **Reneging on promises**: $\lambda = 0$.
3. **Monetization/FTPL** [ala Sargent and Wallace (1981) and Leeper (1991) respectively]: increase in P_1.
4. (only temporary) **Borrowing**: growing debt $B_1 > B_0$.

We explicitly examine solution 2. in which F policy is passive and adjusts λ, and solution 3. in which M policy is passive and adjusts P_1. We consider the former solution to be socially optimal to highlight the fact that F settings should be balanced over the long term.[41] The above reduced-form setup implies that λ and P can be treated directly as instruments of F and M policy respectively.

[40] In the current situation it is certainly important to understand the dynamics of debt, and how it is affected as the economy approaches its F limit. Nevertheless, from a long-term perspective represented by the Normal times scenario what really matters is the *average stance* of the policies.

[41] Obviously, sovereign default may be an optimal short-term solution for an individual country.

A.3. **Active and Passive Policies.** Due to our focus on steady-state outcomes we define A vs P policies differently from Leeper (1991). In his analysis each policy follows a simple dynamic rule. Specifically, the central bank responds to deviations of the price level from its target, $P - P^T$, with a change in its interest rate instrument. The government responds to deviations of real debt from its target, $\frac{B}{P} - b^T$, by adjusting promised net transfers $Z_1 - T_1$. If the policymakers respond sufficiently aggressively to the observed deviation, the policies are called AM and PF. If they respond insufficiently strongly they are labelled PM and AF.

Intuitively, Leeper's (1991) A and P policies refer to *the degree of adjustment of the policy instrument for the purposes of balancing the budget constraint*, which we follow.[42] His analysis however does not pin down the exact strength of policy responses, A and P are defined as a parameter *range* for each policy. To overcome this multiplicity, we depict the two most natural candidates (polar cases) for each regime.

Definition 2. *An **active policy stance,** AM/AF, is such that it provides no adjustment at all to balance the budget constraint (15). In contrast, a **passive policy stance,** PM/PF, is a level P^* and λ^* respectively that provides the full adjustment necessary to balance the budget constraint and keep stable real debt - independently of the other policy (ie assuming the other policy plays A). Formally:*
(i) active fiscal policy AF: choosing $\lambda = 1$;
(ii) active monetary policy AM: choosing $P_1 = P^T$;
(iii) passive fiscal policy PF: choosing $\lambda^* \left(P_1 = P^T, b^T, Z_1, T_1, R_0, B_0\right) < 1$;
(iv) passive monetary policy PM: choosing $P_1^* \left(\lambda = 1, b^T, Z_1, T_1, R_0, B_0\right) > P^T$.

To derive λ^* and P_1^* let us reduce the number of free parameters by normalizing: (a) $R_0 = R_1 = 1$ (which can be interpreted as the 'no discounting' case, and which we will maintain throughout for parsimony), (b) $B_0 = 1$ (which we will consider to be the socially optimal nominal debt level), (c) $P^T = 1$, which implies (d) the social optimal level of real debt, $b^T = 1$, and (e) $Z_1 - T_1 = 2$. Imposing these with $P_1 = P^T$ in (15) yields $B_1 = B_0$, which implies $\lambda^* = 0$. Similarly, the value P_1^* is obtained from (15) by imposing $\lambda = 1$ and $\frac{B_1}{P_1} = b^T = 1$, namely $P_1^* = 2$. Using these normalizations with (15)-(16) and Definition 2 the Normal times outcomes in the four policy regimes are:

(17)

		F	
		PF ($\lambda^* = 0$)	AF ($\lambda = 1$)
M	AM	$\frac{B_1}{P_1} = \frac{1}{1} = b^T$	$\frac{B_1}{P_1} = \frac{3}{1} > b^T$
	PM	$\frac{B_1}{P_1} = \frac{1}{2} < b^T$	$\frac{B_1}{P_1} = \frac{2}{2} = b^T$

A.4. **Policy Preferences.** In order to map the budget constraint to the game theoretic representation (1), we will postulate the policymakers' utility functions - in a way consistent with the standard intuition of the dynamic policy rules of Leeper (1991). The

[42]As Davig and Leeper (2011) explain: *'an active authority is not constrained by current budgetary conditions'*, whereas a passive authority *'maintains the value of government debt'* and *'is constrained by consumer optimization and the active authority's actions'*.

.

preferences can be summarized as follows:

$$U_i = -\phi_i(P_1 - P^T)^2 - \left(\frac{B_1}{P_1} - b^T\right)^2 - \delta_i(1-\lambda)^2, \tag{18}$$

where $i \in \{M, F\}, \phi_i \geq 0$ is the degree of the policymakers' inflation conservatism relative to debt conservatism, and $\delta_i \geq 0$ denotes their aversion to reneging on promised net transfers relative to debt variability.[43] To highlight the primary target of each policy these weights will satisfy:

$$\phi_M > 1 > \delta_M = 0 \;\text{ and }\; \delta_F > \phi_F = 0. \tag{19}$$

We could now postulate the rest of the macroeconomic structure, and derive an optimal setting of the policies through constrained optimization. For our purposes it would however be both a distraction incurring some loss of generality (applicability to a large range of macroeconomic models), and a restriction in terms of the institutional features that can be considered. This is because one can only examine three possible timing scenarios: the simultaneous move, static M leadership, and static F leadership, see eg Dixit and Lambertini (2003). In contrast, our generalized timing of moves will capture dynamic M and F leadership, ie any relative degree of M commitment and F rigidity. To ensure insights are not lost we have selected the most natural candidates for the active/passive policy stance in Definition 2 [for the same mapping of a macro setup to a game theoretic representation see eg Cho and Matsui (2005)].

A.5. **Mapping to the Game Representation.** Combining (17) with (18)-(19) then implies the following payoffs matrix:

(20)

		F	
		PF	AF
M	AM	$0, -\delta_F$	$-4, -4$
	PM	$-\phi_M - \frac{1}{4}, -\delta_F - \frac{1}{4}$	$-\phi_M, 0$

Naturally, we need to impose that $\max\{\phi_M, \delta_F\} < 4$ to ensure that in Normal times the unsustainable regime with explosive debt (AM, AF) is inferior for both policymakers to the regimes (AM, PF) and (PM, AF) in which the budget constraint is balanced. This, with no further assumptions required, implies that we have the Game of Chicken in Normal times summarized by (2), and why most of the literature has used this class of game. To offer a specific example, set

$$\phi_M = 3.8 \;\text{ and }\; \delta_F = 3, \tag{21}$$

used in the payoff matrices (3) and (7) in the main text.

Appendix B. Proof of Proposition 2

Proof. Focus on claim (i) whereby F is the leader. Solving by backwards induction, F knows that when M's revision opportunity comes up, M will play his static best response to F's initial play: both in Downturn and Normal times. Therefore, for F to dominate the game and always play PF' and AF, it is required that F is willing to undergo a

[43] Note that debt variability is closely positively related to output variability, which is a standard component of the central bank's reduced-form preferences.

costly conflict with M: both in Downturn and Normal times. In other words, both PF' and AF have to be the unique best responses not only to PM' and PM respectively, but also to AM' and AM. This will be the case if the subsequent (post-revision) victory gain is sufficiently high to compensate F for the initial conflict cost. Formally, the following incentive compatibility condition needs to hold:

$$p\left(\overbrace{\underbrace{w'\int_0^1 (1-R_M(t))\,\mathrm{d}t}_{(AM',PF')\text{: conflict}} + \underbrace{y'\int_0^1 R_M(t)\mathrm{d}t}_{(PM',PF')\text{: victory}}}^{\text{Downturn}}\right) + (1-p)\left(\overbrace{\underbrace{x\int_0^1 (1-R_M(t))\,\mathrm{d}t}_{(AM,AF)\text{: conflict}} + \underbrace{z\int_0^1 R_M(t)\mathrm{d}t}_{(PM,AF)\text{: victory}}}^{\text{Normal times}}\right) >$$

$$\underbrace{px'}_{(AM',AF')\text{: surrender (Downturn)}} + \underbrace{(1-p)\,w}_{(AM,PF)\text{: surrender (Normal times)}}.$$

Rearranging yields condition (10) and proves claim (i). The proof of claim (ii), made under M being the leader, is analogous due to the symmetry. The proof also implies that unless both (10) and (11) hold there exist multiple types of subgame perfect equilibrium payoffs, so neither player dominates. This means that both short-term deflation and long-term inflationary spillovers may occur in this intermediate Regime switching region. Using 5, 6, and 20 the threshold can be written as

$$T_M = \frac{4pD - 17p + 16}{15p + 4\delta_F} \quad \text{and} \quad T_F = \frac{4pD - 32p + 16}{15p + 4\phi_M}, \tag{22}$$

which, by inspection, completes the proof. □

Appendix C. Quantification of F Rigidity and Long-term M Commitment

Measure	F1	F2	F3-5	F6-8
Measure name	Fiscal Balance	Fiscal Space	Fiscal Space	Fiscal Responsibility
Measure by	IMF	Aizenman & Jinjarak (2011)	Ostry et al. (2010)	Augustine et al. (2011)
Data period	Average 2001-11	2011 debt over avg 2001-11 tax base	Projected future	Projected future
Measure type	Budget surplus to GDP	Public debt to GDP to tax base to GDP	Probability of F space (% GDP) 3. $FS > 0$ 4. $FS > 50$ 5. $FS > 100$	6. F space: % GDP to debt ceiling 7. F path: # years to debt ceiling 8. F governance index out of 100

Table 2. Components of our fiscal rigidity index

Table 2 summarizes the eight measures of F rigidity that enter our overall index with equal weights. Measures 1-2 reflect past outcomes, measures 3-7 are based on the projected future outcomes, and measure 8 expresses F governance, which is their important determinant. The 'under-representation' of the commonly used measures 1-2 reflects the fact that the much larger size of the F gap appears in the future.

Measure	M1	M2	M3	M4
Measure name	Political Transparency	Final Responsibility	Inflation Focus	Accountability
Measure by	Eijffinger & Geraats (2006)	Haan et al. (1999)	Fry et al. (2000)	Fry et al. (2000)
Quantified by	Dincer & Eichengreen (2009)	Sousa (2002)	Fry et al. (2000)	Fry et al. (2000)
Data period	Average 1998-2006	2002	1998	1998
Measure type	index out of 3	index out of 6	index out of 100	index out of 100

TABLE 3. Components of our long-term monetary commitment index

Table 3 summarizes the four measures of M commitment that enter our overall index with equal weights. For reasons implied in Section 6 we only quantify the measure for countries possessing autonomous M policy, ie we do not include countries within (or pegged to) the Euro. Table 4 reports the data from the papers of Tables 2-3.

It should be said that our ranking of countries is fairly robust to alternative weighting of the underlying measures due to their high positive correlation, see Table 5.[44] To adjust for different units of the underlying measures we normalize all values on the $[0, 1]$ interval. As some of the measures do not have a natural lower and/or upper bound, we assign the polar values 0 and 1 to the minimum and maximum appearing in our sample (of 25 countries for F rigidity and 12 countries for M commitment). Table 6 reports the resulting scores, as well as their ratio and country ranking.

Appendix D. Proof of Proposition 3

Proof. Focus on claim (i) in which M is the reviser, and solve backwards. When M's revision opportunity arrives his best response to the ambitious governments' (PF', AF) must uniquely be (PM', PM). Formally, we have the following necessary condition

$$\begin{aligned} &p\left(f^A c' + f^R d' + f^U c'\right) + (1-p)\left(f^A d + f^R c + f^U d\right) > \\ &p\left(f^A a' + f^R b' + f^U a'\right) + (1-p)\left(f^A b + f^R a + f^U b\right), \end{aligned} \tag{23}$$

which, after rearranging, yields (12). Intuitively, the proportion (probability) of the F^A and F^U types, relative to the F^R type, has to be sufficiently high to sway M to comply with them. If satisfied, the central bank would choose to go into conflict with the F^R government types rather than the F^A and F^U types to minimize its associated conflict cost. This is despite the bank being postulated as responsible.

44 Island and Hungary are two possible exceptions whereby some of their recent developments may not be fully captured.

Measure	F1	F2	F3	F4	F5	F6	F7	F8	M1	M2	M3	M4
Australia	0.26	0.66	99.8	99.5	99.5	168	40+	65.9	3	5	94	83
Canada	−0.78	2.09	92.2	92.1	70.3	106	39	51.5	3	4	88	100
Hungary	−5.32	1.71				53.2	12	46.1	2.67	2	19	83
Iceland	−0.73	2.28	49.1	44	5.8	17.1	20	20.2	3	4	19	92
Japan	−6.7	7.75	0.1	0.1	0.1	49	5	47.2	1.5	3	50	50
Korea	1.63	1.42	100	100	100	124.9	40+	27.5	3	4	63	83
New Zealand	0.88	1.11	93.3	93	92.1	164	38	68.5	3	4	94	100
Norway	13.19	0.97	100	100	100	171.6	22	47.9	2	5	0	50
Poland	−5.08	1.44				94.9	31	58	2.89	3	94	58
Sweden	0.8	0.69	99.9	99.9	99.9	154	40+	59	2.44	1	100	83
UK	−4.6	2.18	78.1	75.9	8.9	91	27	66.4	3	4	100	100
USA	−5.52	3.09	71.8	52.2	1.2	62	16	46	1	2	19	83
Austria	−2.28	1.48	97.9	97.8	75.1	76.4	12	67.8				
Belgium	−1.61	1.93	95.9	89.7	2.9	42.3	8	61.2				
Denmark	1.06	0.8	100	100	100	153.1	34	54.7				
Finland	2.04	0.95	96.2	96	69.3	99.2	13	57.9				
France	−4.06	1.74	88.7	86.6	12	58.7	15	62.8				
Germany	−2.46	1.87	93	92.3	35.3	75.7	18	57.4				
Greece	−7.64	4.21	6.3	0.1	0.1	0	0	45				
Ireland	5.2	3.21	66	55.9	1.7	38.1	6	48.4				
Italy	−3.54	2.67	17.3	1.7	0.2	17.8	7	59.2				
Netherlands	−1.9	1.46	99.3	99.2	83.1	92.7	12	72.3				
Portugal	−3.47	2.62	34.4	27.1	0.4	27.8	5	45.1				
Slovakia	−4.59	1.3				107.7	33	50.9				
Spain	−2.5	1.77	69.9	61	1.6	81.5	12	60.7				

Table 4. Original values of the underlying measures from Tables 2-3.

Measure	F1	F2	F3	F4	F5	F6	F7	F8	M1	M2	M3	M4
F1	-	0.59	0.57	0.62	0.69	0.63	0.29	-0.07	-0.17	-0.44	0.32	0.32
F2	0.59	-	0.94	0.92	0.70	0.66	0.80	0.20	-0.56	-0.23	-0.25	-0.46
F3	0.57	0.94	-	0.98	0.79	0.78	0.84	0.30	-0.45	-0.19	-0.31	-0.39
F4	0.62	0.92	0.98	-	0.85	0.83	0.88	0.33	-0.54	-0.26	-0.38	-0.35
F5	0.69	0.70	0.79	0.85	-	0.91	0.79	0.26	-0.42	-0.24	-0.32	0.00
F6	0.63	0.66	0.78	0.83	0.91	-	0.69	0.58	-0.28	-0.24	-0.39	0.04
F7	0.29	0.80	0.84	0.88	0.79	0.69	-	0.31	-0.73	-0.14	-0.67	-0.58
F8	-0.07	0.20	0.30	0.33	0.26	0.58	0.31	-	-0.09	0.01	-0.66	-0.19
M1	-0.17	-0.56	-0.45	-0.54	-0.42	-0.28	-0.73	-0.09	-	0.49	0.57	0.64
M2	-0.44	-0.23	-0.19	-0.26	-0.24	-0.24	-0.14	0.01	0.49	-	-0.10	-0.01
M3	0.32	-0.25	-0.31	-0.38	-0.32	-0.39	-0.67	-0.66	0.57	-0.10	-	0.57
M4	0.32	-0.46	-0.39	-0.35	0.00	0.04	-0.58	-0.19	0.64	-0.01	0.57	-

Table 5. Cross-correlation of our institutional measures.

Country	Code	F rigidity		M commitment		M commitment to F rigidity scores	
		Score	Rank	Score	Rank	Ratio	Rank
Australia	AUS	0.19	24	0.93	2	4.94	1
Canada	CAN	0.35	16	0.91	4	2.61	5
Hungary	HUN	0.63	7	0.52	9	0.82	10
Iceland	ISL	0.70	5	0.71	7	1.01	9
Japan	JAP	0.89	1	0.41	11	0.46	12
Korea	KOR	0.31	19	0.79	5	2.57	6
New Zealand	NZL	0.21	21	0.92	3	4.30	2
Norway	NOR	0.18	25	0.47	10	2.68	4
Poland	POL	0.49	11	0.72	6	1.46	8
Sweden	SWE	0.21	22	0.63	8	3.03	3
UK	GBR	0.48	14	0.94	1	1.96	7
USA	USA	0.63	8	0.31	12	0.49	11
Austria	AUT	0.34	17				
Belgium	BEL	0.49	12				
Denmark	DEN	0.23	20				
Finland	FIN	0.33	18				
France	FRA	0.48	13				
Germany	GER	0.43	15				
Greece	GRE	0.87	2				
Ireland	IRL	0.65	6				
Italy	ITA	0.75	3				
Netherlands	NED	0.2	23				
Portugal	POR	0.73	4				
Slovakia	SVK	0.49	10				
Spain	ESP	0.54	9				

Table 6. Our F rigidity and M commitment indices and their ratio.

Moving backwards, at time $t = 0$ both the F^A and F^U types of government have to play uniquely (PF', AF) in equilibrium, regardless of M's initial play. For F^U this is automatically satisfied (as she has a strictly dominant strategy in the underlying game), and for F^A this is - assuming (23) holds - ensured by (10) derived in the benchmark specification. Then we know that the exit strategy will surely be unsuccessful, as M will play (PM', PM) from $t = 0$. In terms of claim (ii), M knows that while the actions of F^R and F^U type governments are independent of M's actions, the F^A type's revision will be the static best response to M's initial play. Using this information implies that for M to uniquely play (AM', AM) the following incentive compatibility has to hold

$$f^A\left\{p\left[a'\int_0^1(1-R_F(t))dt + b'\int_0^1 R_F(t)dt\right] + (1-p)\left[b\int_0^1(1-R_F(t))dt + a\int_0^1 R_F(t)dt\right]\right\} + f^R[pb' + (1-p)a] + f^U[pa' + (1-p)b] > f^A[pc' + (1-p)d] + f^R[pd' + (1-p)c] + f^U[pc' + (1-p)d].$$

This, after rearranging, yields (13), which is just a generalized version of (11). Equation (13) suggests that if its denominator is non-positive then the T_F threshold does not exist. This implies the necessary condition (14) and completes the proof. □